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Data Visualization and Animation Lab: Applications

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A wide variety of software tools in DVAL have been successfully used to visualize, analyze, and present computational and experimental data at Langley Research Center. These tools can be roughly categorized according to five primary uses: 2-D image analysis, conventional 3-D visualization, volume visualization, photo-realistic rendering, or special-purpose applications. Software in each of these categories is accessible to LaRC personnel free of charge, and training or consultation can be arranged with the DVAL staff.

Two-dimensional image analysis software is supported on many platforms and provides several fundamental capabilities. The input is generally a 2-D array of bits, bytes, integers, floating-point, or even complex numbers. These arrays can then be represented as color images from which features can be enhanced, extracted, and statistically analyzed. Images can also be represented as contour plots or, by correlating height with a scalar quantity, as 3-D surfaces. Most image analysis tools in use today support two levels of users: the programmer, who intends to incorporate their own algorithms usually through a command-line interface, and the novice end-user who usually prefers to work with a straightforward menu interface. Advanced features include image segmentation and pattern recognition capabilities.

The two primary image analysis packages available in DVAL are PV~WAVE and KB-Vision, both of which have been successfully applied to several LaRC projects. PV~WAVE, a product of Visual Numerics Inc. runs on most UNIX workstations, and multiple licenses are available which can be shared among LaRC researchers. A more advanced product, KB-Vision from Amerinex Artificial Intelligence Inc., employs artificial intelligence techniques to provide state-of-the-art feature extraction and pattern-recognition capabilities. KB-Vision has been used to analyze and reduce images acquired from an in-flight experiment which utilized tufts, and from a spin-tunnel test which utilized retro-reflective targets.

Software which allows interactive visualization of 3-D data was originally specialized for computational fluid dynamics solutions on high-end workstations. Today, tools are available even on modest computing platforms for visualizing dense data from either computational or experimental sources. These conventional tools generally input volume grids, scalar quantities, and vectors in either structured or unstructured format. Arbitrary cross-sectional surfaces through the data can be displayed and colored according to a selected parameter. Advanced features include iso-surfaces (the 3-D extension of a contour), transparency, thresholding, stereo display, and animation.

Three primary scientific visualization packages used at the Center include the Flow Analysis Software Toolkit (F.A.S.T.), Tecplot, and Fieldview. Although these tools were originally intended for CFD research, they have been successfully used to analyze a variety of datasets including those from wind tunnel or in-flight tests, atmospheric simulations, structural analyses, and medical scans. F.A.S.T., a highly interactive environment often used in DVAL to produce animations of 3-D data, is supported on Silicon Graphics (SGI) workstations and is free to all NASA personnel and contractors. Tecplot is free of charge to LaRC personnel and is available on SUN, SGI, DEC, HP, IBM, and PC platforms. Fieldview, by Intelligent Light, Inc., is supported on all major UNIX workstations, and a limited number of licenses are available at LaRC upon request.

Volume visualization techniques offer an alternative to the more traditional visualization tools. Whereas the conventional tools require the user to extract polygonal approximations such as cutting planes and iso-surfaces from their data, volume visualization tools can potentially render an entire volume of data, allowing simultaneous examination of surfaces and internal

structures. This technique is particularly applicable to the analysis of diffuse or "fuzzy" 3-D phenomenon which have no clear boundaries, such as electromagnetic fields. Current volume rendering technology requires the volume to be a rectangular parallelepiped (a box) which is furthermore subdivided into cubic building blocks, called voxels. A value (upto 16 bits) for some measured or calculated property is associated with each voxel. The usefulness of volume visualization has been demonstrated in a number of fields including cell biology, medical imaging, nondestructive testing, molecular modeling, astrophysics, and multi-dimensional mathematics. A high-end volume rendering package called VoxelView by Vital Images, Inc. is supported on SGI and Macintosh platforms and is available for use in DVAL.

When a very high-quality computer-generated image or animation is necessary to describe an otherwise abstract idea or phenomenon, photo-realistic rendering software is required. The Wavefront Advanced Visualizer available in DVAL serves this purpose by providing a menu-driven environment in which such effects as textures, shadows, reflection, refraction, and transparency can be simulated and applied to complex, moving objects. The objects can be modeled within Wavefront or can be imported from other packages such as PLOT3D or IDEAS. This software has proven useful in several areas, primarily in the description of an experimental facilities such as wind tunnels in which interior structures of interest are often inaccessible to conventional cameras. Similarly, many phenomenon which are too small, too large, too abstract, or simply non-accessible have been simulated with this rendering package. Specific applications have included the depiction of a water tunnel experiment, the simulation of shuttle arm flexing due to heavy payloads, the internal structure of multi-layered I-beams, and the simulated take-off of the High Speed Civil Transport. Two copies of the Wavefront Advanced Visualizer are available on DVAL SGI workstations (with 4-CPUs each), and staff is available to produce requested animations or train interested individuals.

A special-purpose application program has been designed in DVAL to support flow visualization experiments which utilize cameras and lightsheets. The software, termed ILLUME (Interactive Lightsheet Locator Utility and Modeling Environment), provides an interactive capability for determining suitable placement of cameras and lightsheets well in advance of the actual experiment and before any instrumentation is configured in a tunnel or on an aircraft. The software allows the user to position cameras and light sheets with respect to the test object or model and see simulated camera views. Adjustments can be made to the camera and light sheet positions and orientations until the desired view is obtained. In addition, roll, pitch, and yaw adjustments can be made to the model to determine whether all desired regions of the model remain visible to the recording camera for a range of test conditions. ILLUME is an OSF/Motif-based program which runs on most SGI workstations, accepts PLOT3D grid and function files, and is freely availabe to LaRC researchers.

Information about all of the packages mentioned can be obtained through the following e-mail addresses:

PV~WAVE	pvwave-request@hojo.larc.nasa.gov
KB-Vision	isdcs+iphelp@larc.nasa.gov
Tecplot	tecplot@eagle.larc.nasa.gov
Fieldview	j.t.bowen@larc.nasa.gov
F.A.S.T.	isdcs+vizhelp@larc.nasa.gov
VoxelView	isdcs+vizhelp@larc.nasa.gov
Wavefront	isdcs+vizhelp@larc.nasa.gov
ILLUME	isdcs+vizhelp@larc.nasa.gov

1994 Workshop
The Role Of Computers in LaRC R&D
Graphics and Image Processing Session
June 16, 1994

DATA VISUALIZATION & ANIMATION LAB (DVAL) APPLICATIONS

Presented by:
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Mike Weisenborn

Outline

Image Analysis Software

Standard Scientific Visualization Software

Volume Visualization Software

Photo–realistic Rendering Software

Special–purpose Visualization Software

DVAL APPLICATIONS

Image Analysis Software

- inputs arrays of bit, byte, integer, or floating–point data
- color image display, enhancement, feature extraction, and statistics
- line, contour, and surface plots
- programmer or end–user level

PV~WAVE

pvwave–request@hojo

- Visual Numerics, Inc.
- command–line language
- some 3–D analysis capabilities
- most UNIX workstations

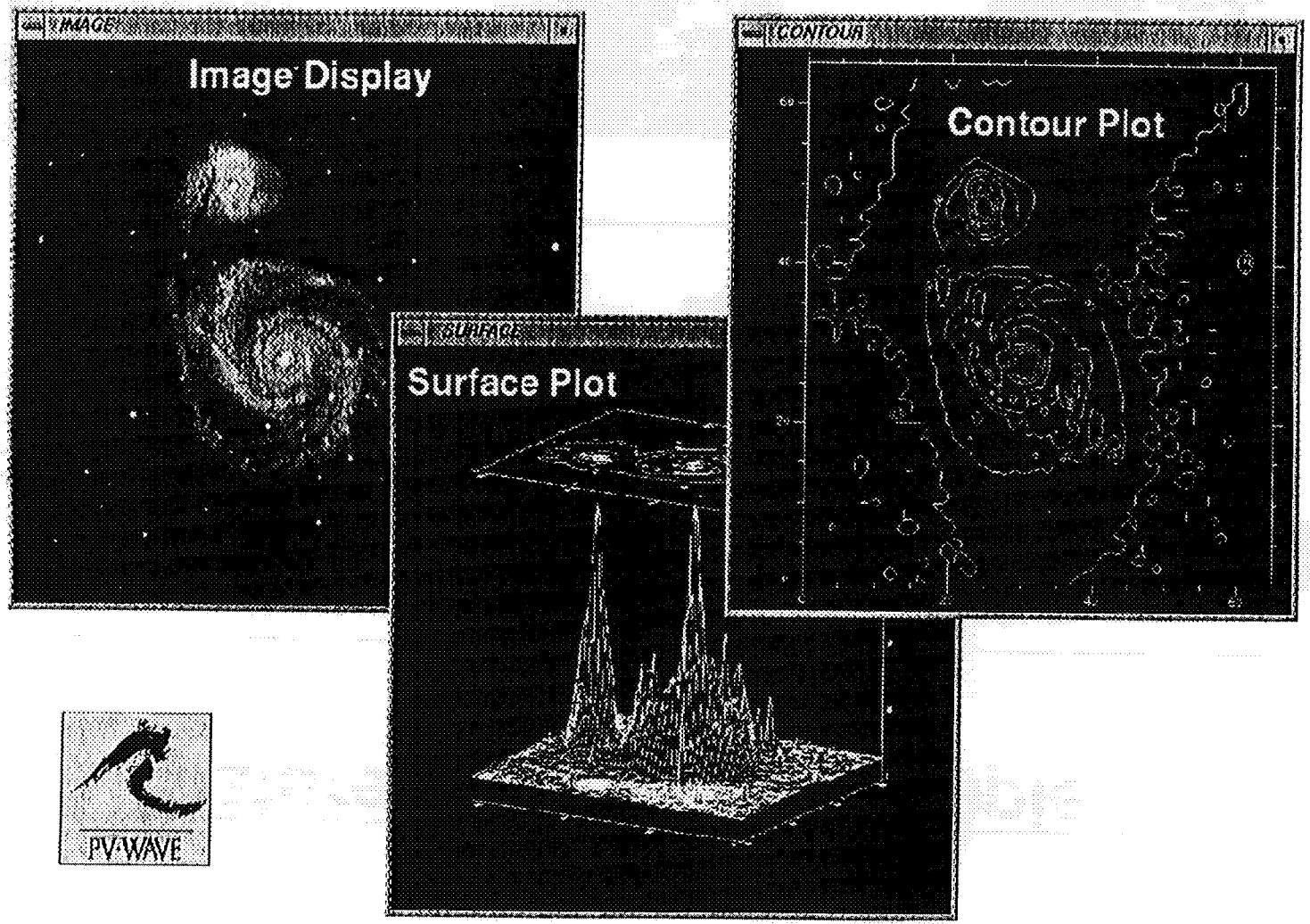
KBVision

isdcs+iphelp@larc

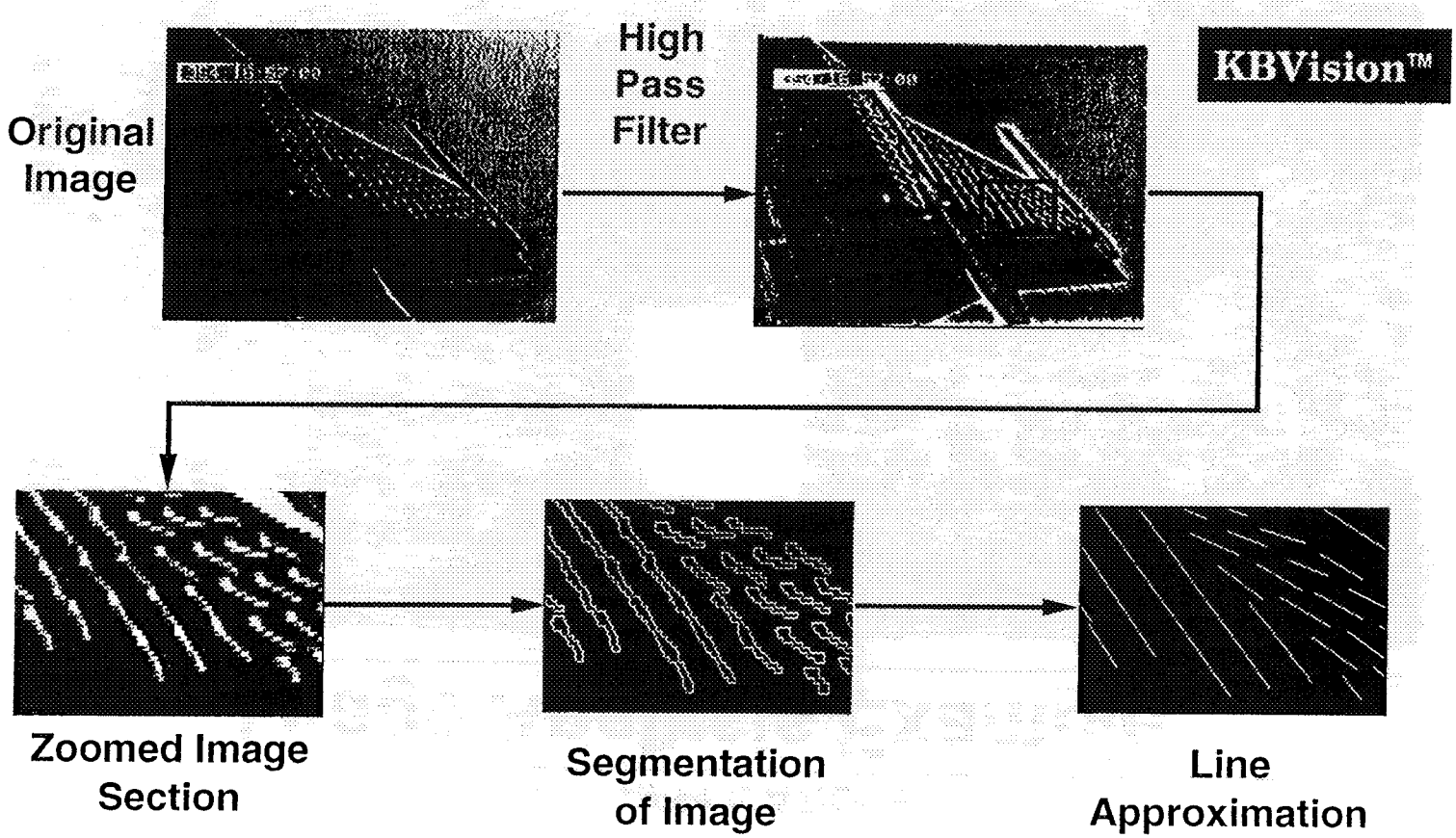
KBVision™

- Amerinex Artificial Intelligence, Inc.
- employs state–of–the–art A.I. techniques
- well–suited for feature extraction and pattern recognition
- most UNIX workstations

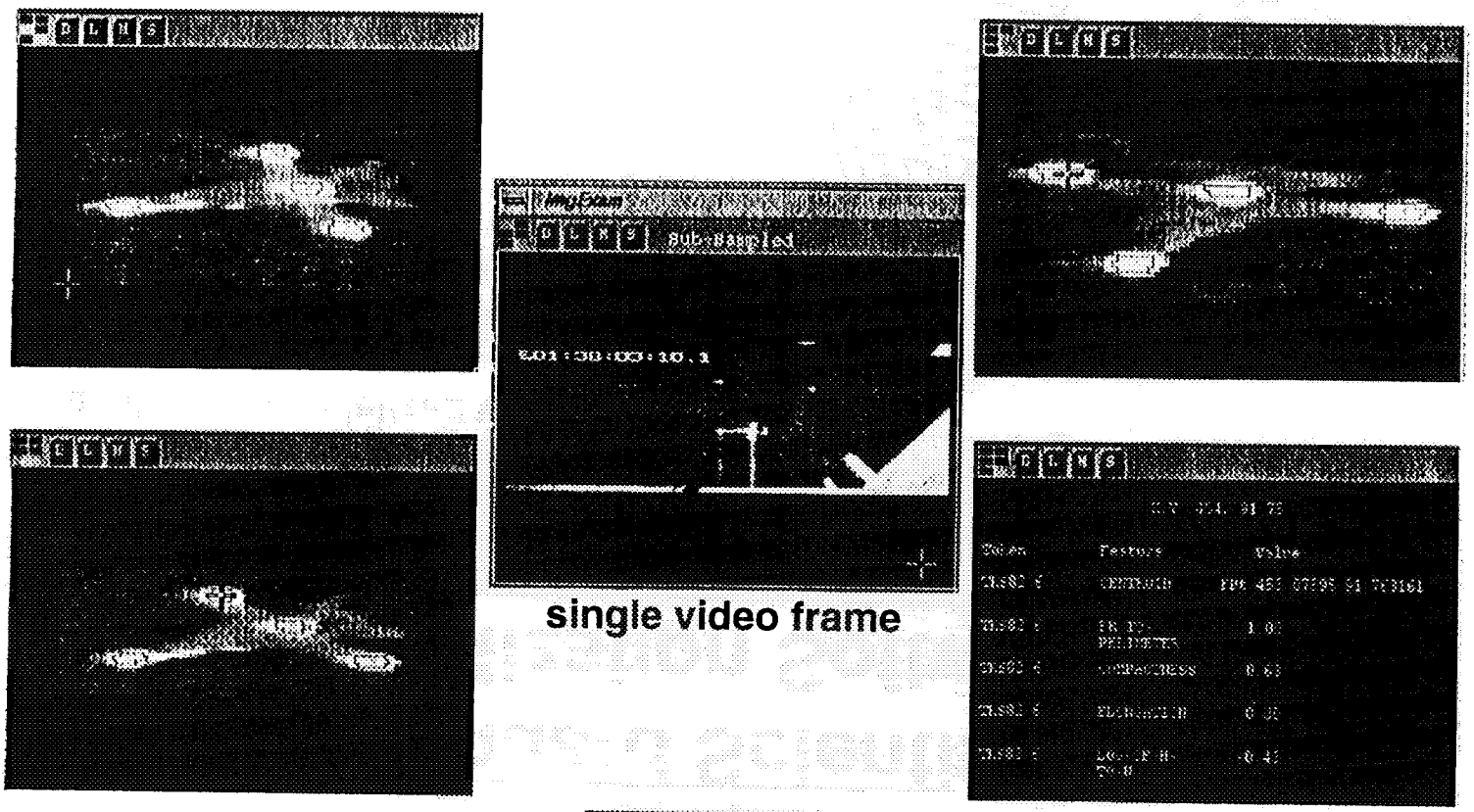
Image Analysis Example



Feature Extraction Example: Tuft Images



Feature Extraction Example: Spin Tunnel Images



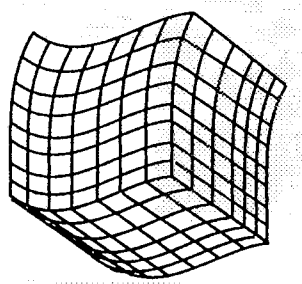
single video frame

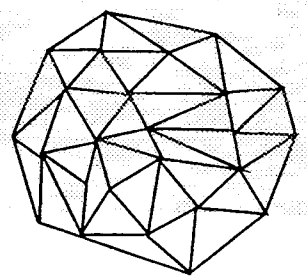
KBVision™

Standard Scientific Visualization Software

HISTORY:

- evolved from software originally designed to analyze CFD results on specialized workstations
- now available on a variety of platforms and useful in analyzing practically any experimental or computational data





GENERAL CAPABILITIES:

- 3–D structured or unstructured grids:
- highly interactive environment
- arbitrary cross–sectional surfaces through the data
- contoured or colored surfaces according to scalar quantities
- iso–surfaces
- vector fields
- particle traces

Standard Scientific Visualization Software

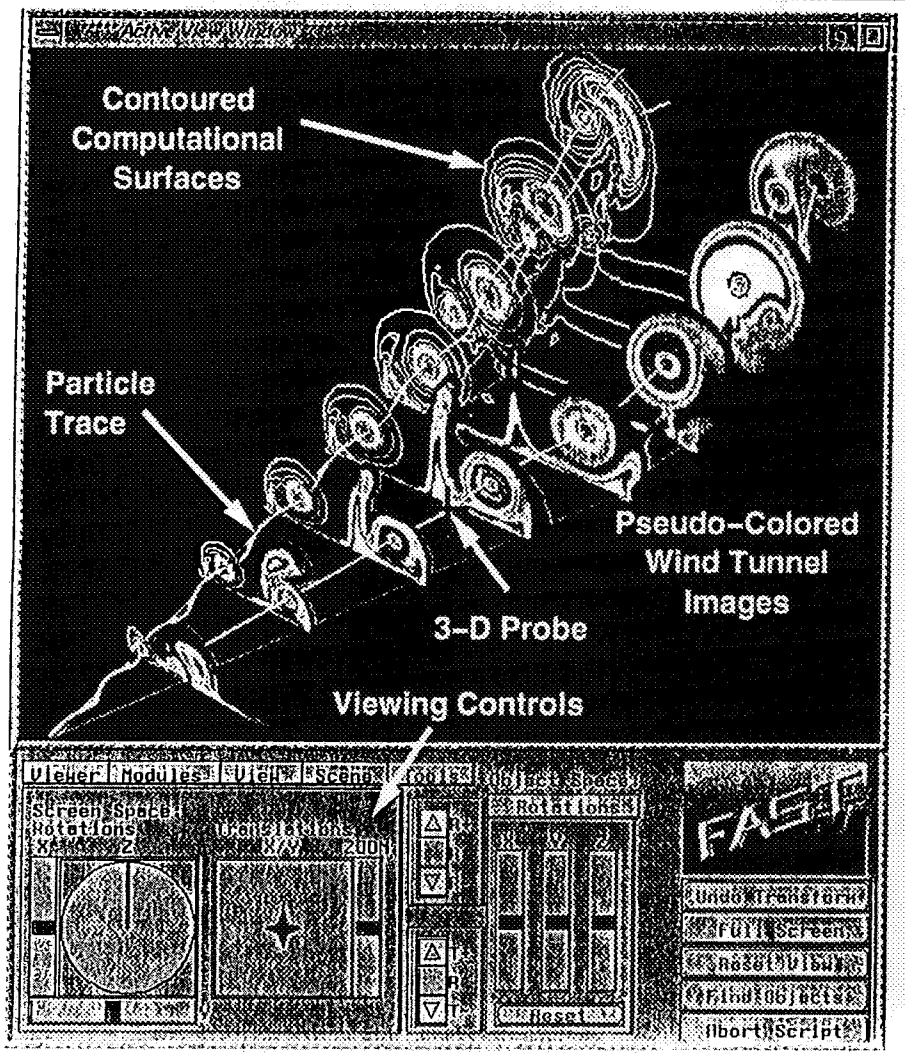
WIDELY–USED PACKAGES:

Flow Analysis Software Toolkit (F.A.S.T) — isdcs+vizhelp@larc
- Ames Research Center / Sterling Software
- only SGI workstations
- free to NASA

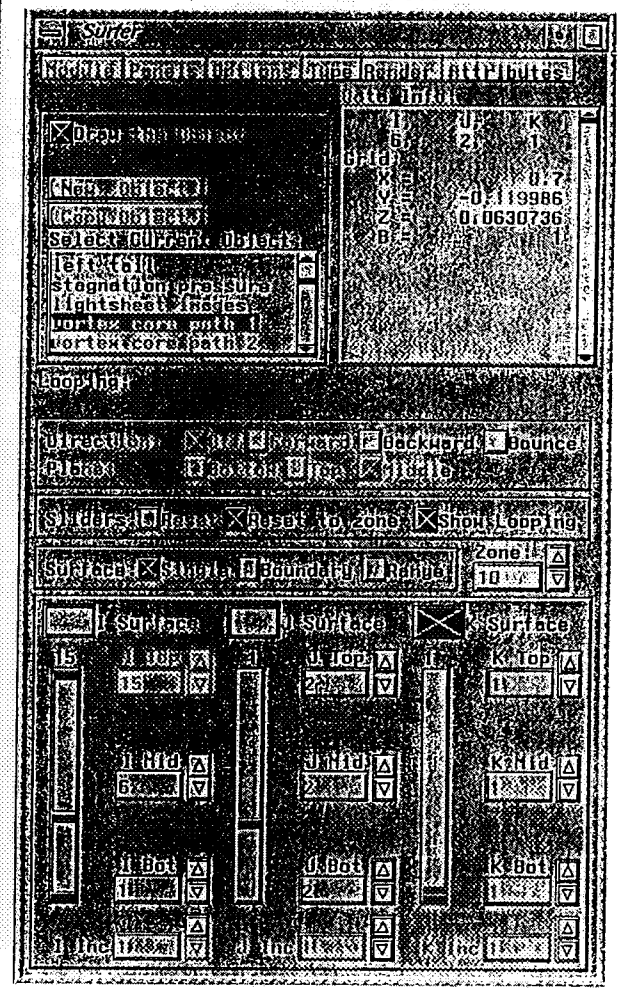
Fieldview — j.t.bowen@larc
- Intelligent Light, Inc.
- all major UNIX workstations
- limited number of licenses available

Tecplot — tecplot@eagle
- Amtec Engineering, Inc.
- SUN, SGI, DEC, HP, IBM, PC
- available at LaRC upon request

Flow Analysis Software Tookit

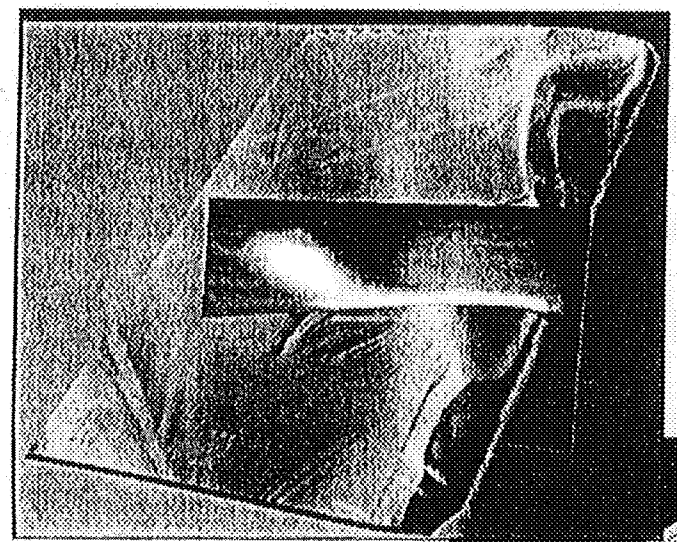


Surface Controls

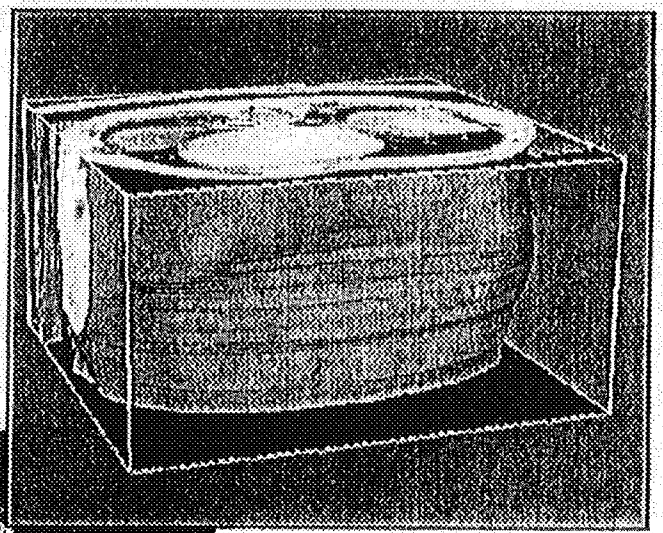


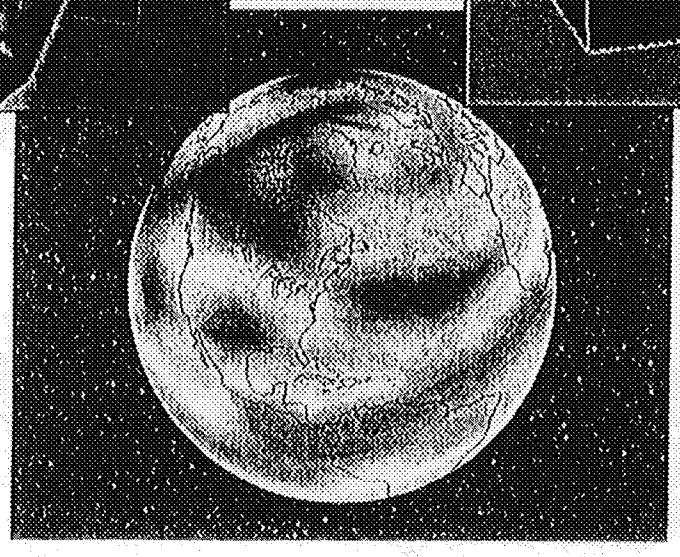
Other Applications

Flight Data



Medical Data





Atmospheric Data

DVAL APPLICATIONS

Volume Visualization Software

FEATURES:

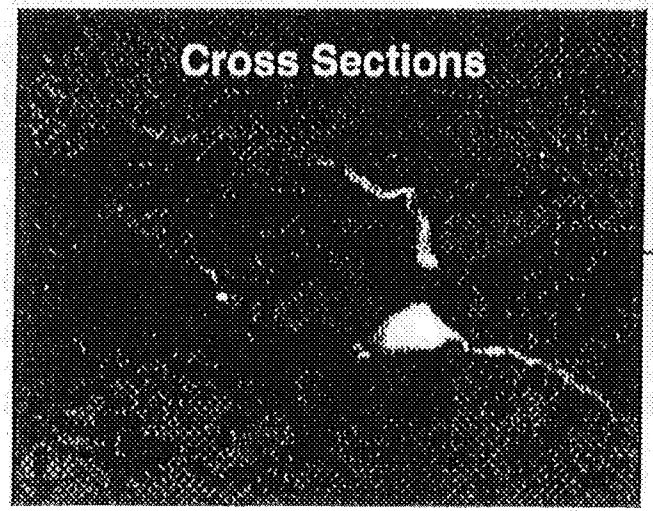
- combines the concepts of image processing and computer graphics to visualize an entire volume of scalar data
- requires the volume to be subdivided into regularly–spaced cubes
- well–suited for "fuzzy" or diffuse distributions of 3–D data

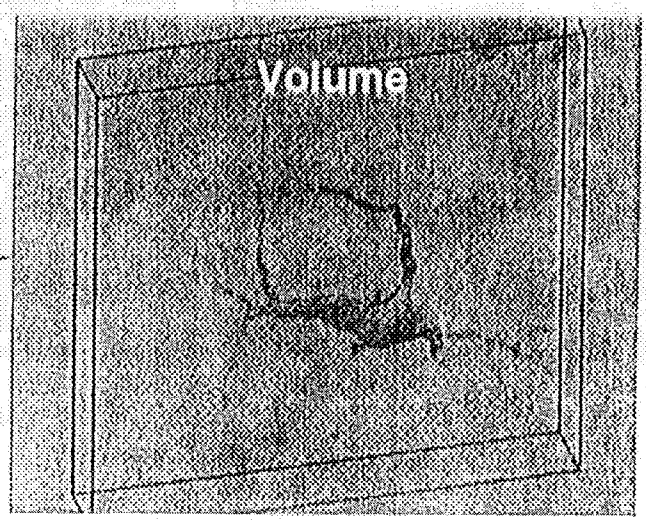
ADVANTAGES OVER CONVENTIONAL (POLYGONAL) TECHNIQUES:

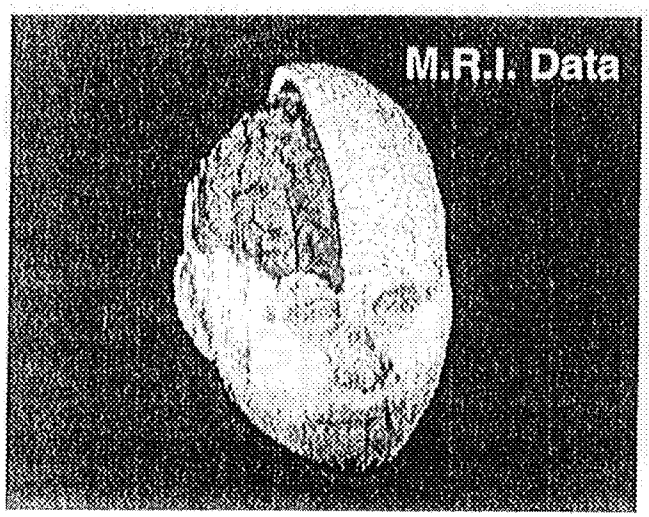
- unnecessary to create a polygonal approximation
- allows phenomena without clear boundaries (i.e., energy fields) to be represented accurately
- internal structures easily examined using transparency

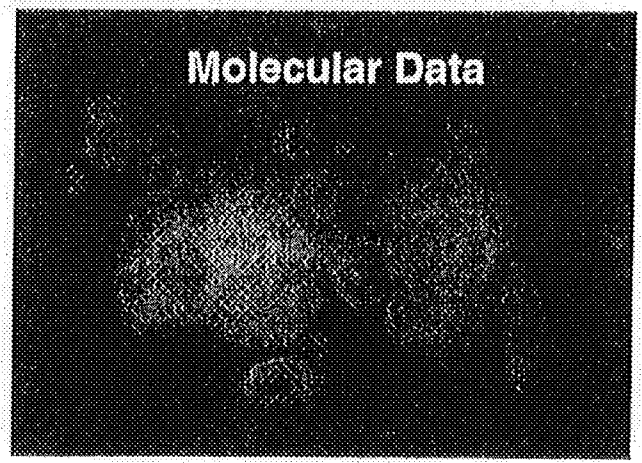
AVAILABLE IN DVAL: VoxelView, by Vital Images, Inc.

VoxelView: Examples







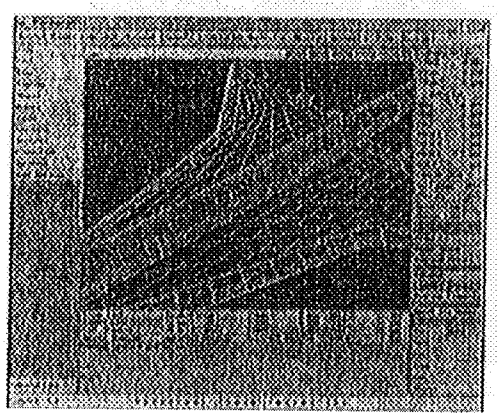


DVAL APPLICATIONS

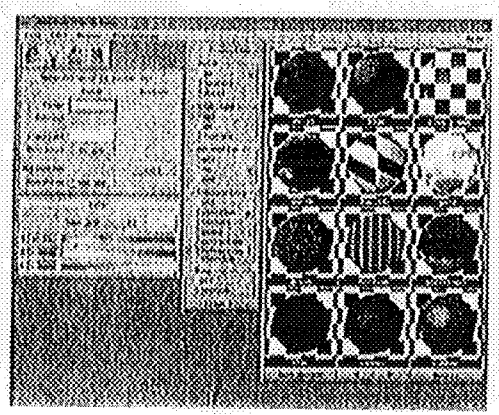
Wavefront Advanced Visualizer

- Photorealistic Computer Animation
- Used for Still Images and Animation Sequences

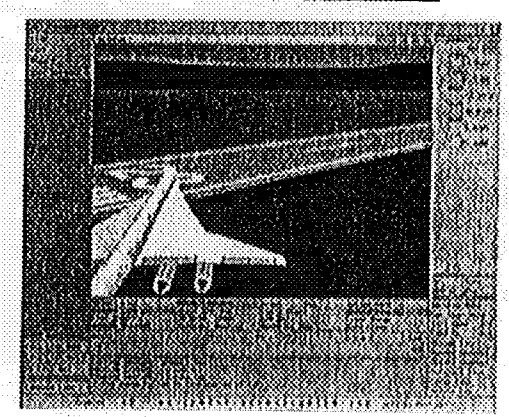
Object Modeling



Material Editing



Motion Definition

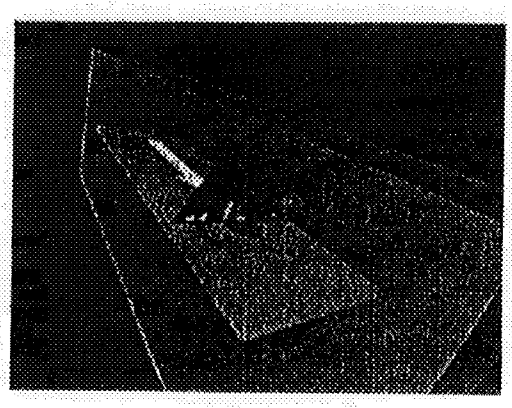


Scientific Applications

- Display Experimental Setup
- Demonstrate Unobservable Phenomena
- Show Internal Structure of Objects
- Visually Simulate Future Technology

WATER TUNNEL SETUP

- Photographs can not fully demonstrate the experimental setup.
- Computer animation can dissolve certain features to clarify setup.



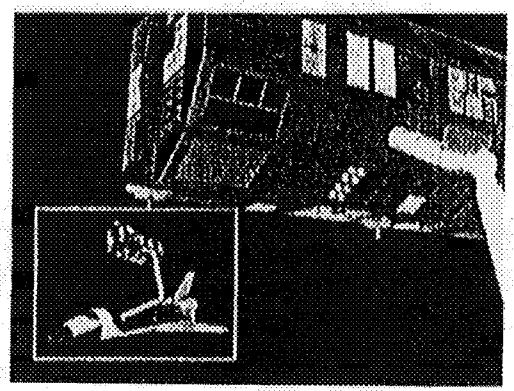
DVAL APPLICATIONS

Scientific Applications

- Display Experimental Setup
- Demonstrate Unobservable Phenomena
- Show Internal Structure of Objects
- Visually Simulate Future Technology

SHUTTLE ARM CONTROL

- Researchers were investigating methods to control flex in arm.
- Computer animation allowed exaggeration and demonstration of flex.



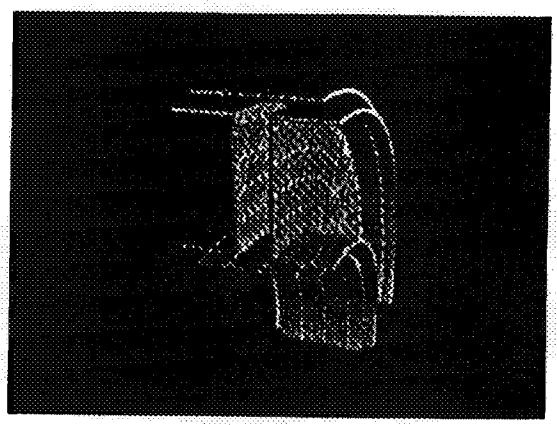
DVAL APPLICATIONS

Scientific Applications

- Display Experimental Setup
- Demonstrate Unobservable Phenomena
- **Show Internal Structure of Objects**
- Visually Simulate Future Technology

I–BEAM STRUCTURE

- **I–beams were constructed with multiple layers.**
- **Computer animation allowed demonstration of internal structure.**



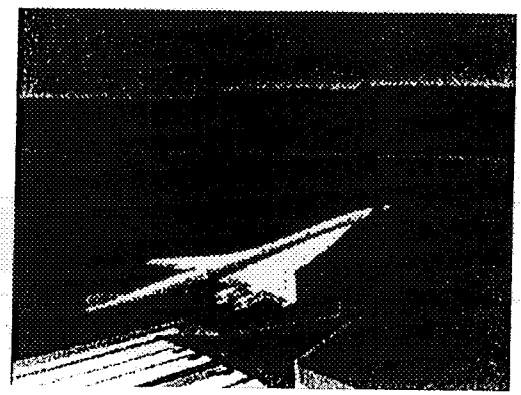
DVAL APPLICATIONS

Scientific Applications

- Display Experimental Setup
- Demonstrate Unobservable Phenomena
- Show Internal Structure of Objects
- Visually Simulate Future Technology

HIGH SPEED CIVIL TRANSPORT

- Aircraft is still in design phase.
- Computer animation provided a preliminary view of the aircraft.

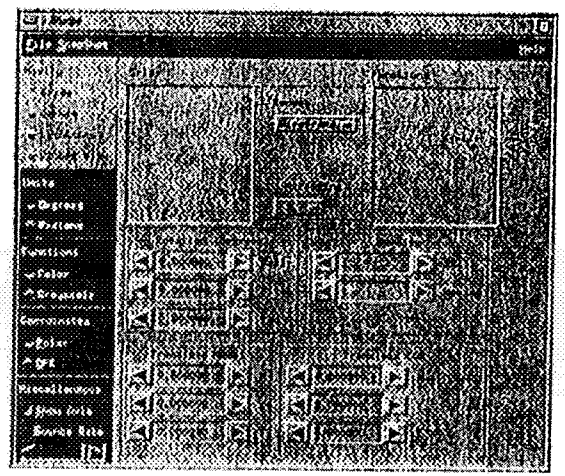


Wavefront in DVAL

- Two copies of the Advanced Visualizer
- Running on 4–CPU Silicon Graphics Workstations
- Assistance is available for learning Wavefront
- DVAL staff with expertise in using Wavefront

ILLUME

- Interactive Lightsheet Locator Utility and Modeling Environment
- Designed to ease setup of experiments involving cameras and lightsheets.
- Developed in DVAL – local expertise
- Graphical User Interface (MOTIF)



ILLUME Controls

- Camera position and orientation
- Up to 6 Cameras

- Lightsheet position, orientation, and type (rotating or translating)
- Up to 6 Lightsheets

- Model translation, roll, pitch, and yaw
- Uses Plot3D gridfiles for geometry
- Allows function mapping onto grids

SESSION 8 System Design and Integration

Chaired by

Jerry H. Tucker

8.1 The Design Manager's Aid for Intelligent Decomposition DeMAID - Jim Rogers

8.2 RDD-100 and the Systems Engineering Process - Robert Averill

8.3 Computer Tools for Systems Engineering at LaRC - J. Milam Walters

8.4 A Distributed Computing Environment for Multidisciplinary Design FIDO - Robert Weston

8.5 An Overview of the Computer Aided Engineering and Design for Electronics Laboratory CAEDE - Shelley Stover

8.6 The Software Engineering and/or Ada Lab (SEAL) - Robert Kudlinski